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DAIRY FARM RADIOIODINE STUDY FOLLOWING THE PIKE EVENT

By
Delbert S. Barth
Joel G. Veater

November 23, 1964

Public Health Service
Southwestern Radiological Health Laboratory
Las Vegas, Nevada

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HEALTH AND SAFETY
(TID-4500, 41st Ed.)

DAIRY FARM RADIOIODINE STUDY FOLLOWING THE PIKE EVENT

by
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Bioenvironmental Research Program
Southwestern Radiological Health Laboratory
U. S. Public Health Service
Department of Health, Education, and Welfare
Las Vegas, Nevada

November 23, 1964

This study performed under a Memorandum of
Understanding (No. SF 54 373)
for the
U. S. ATOMIC ENERGY COMMISSION

ABSTRACT

Following the Pike Event at the Nevada Test Site on March 13, 1964, a small amount of radioactivity accidentally escaped from the ground. The resulting radioactive cloud passed over two dairy farms in the vicinity of Las Vegas, Nevada. Arrangements were made with the managers of these farms to cooperate in a study of the uptake kinetics of I^{131} in dairy cattle under normal dairy farming practices.

Each herd was separated so that at each farm there were three cows eating fresh green chop with the remainder of the herd on hay and stored feed. Peak levels observed in the milk of cows on green chop were 420 picocuries per liter (pc/l) at one farm and 70 pc/l at the other with an apparent decay half-life of approximately four days for both. Peak levels in the milk of cows on hay were 70 pc/l at one farm and 40 pc/l at the other. The apparent decay half-life at the farm having the highest levels was approximately six days.

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ACKNOWLEDGEMENTS

We wish to extend special thanks to the owners and operators of the two farms. In particular, these include Mrs. Eunice Habbart, Mr. Floyd Miles and Mr. Nelson Gibson at the Habbart Farm, and Mr. Blaine Curtis, Supervisor, and Mr. Lynn Duke, Dairy Manager at the Latter Day Saints' Welfare Farm. Without the cooperative help of these people and their associates, this study would not have been possible. The support and encouragement of Mr. Robert Thalgott, Nevada Operations Office, Atomic Energy Commission, is gratefully acknowledged. The liaison and cooperation of Mr. Ferren Bunker, Clark County Extension Agent, and Mr. W. W. White of the Nevada State Health Department were also of considerable assistance in our investigation. There were many friends and co-workers, too numerous to mention, at the Southwestern Radiological Health Laboratory who made valuable contributions and suggestions throughout the study.

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Part I

INTRODUCTION

Radioactivity was accidentally released from the underground Pike Event which took place at the Nevada Test Site at 0802 hours on March 13, 1964. A portion of this material passed over the city of Las Vegas, Nevada and parts of Clark County. In particular, some fallout was deposited on and in the vicinity of two dairy farms located near Las Vegas. These two farms were:

Latter Day Saints' Church Welfare Farm
6206 Munson Road, Las Vegas, Nevada and

Mrs. Habbart's Dairy Farm
6912 Pecos Road, Las Vegas, Nevada

The location of each farm is shown in Figure 1 in the Appendix. Some descriptive information concerning the two farms will be found in Figures 2 and 3 in the Appendix. The milk census forms constituting Figures 2 and 3 are representative of the records maintained by the Southwestern Radiological Health Laboratory for milk producers in Nevada and adjacent states.

This accidental occurrence provided a unique opportunity to study the uptake of radioiodine into cow's milk under dairy farming management conditions as practiced at these two farms. A plan was developed to conduct a cooperative study between the Bioenvironmental Research Program, Southwestern Radiological Health Laboratory, U. S. Public Health Service, and the local dairy industry with the support of the Nevada Operations Office, Atomic Energy Commission. The design of the study was discussed with Mr. Ferren Bunker, Clark

County Extension Agent representing the University of Nevada. Also Mr. W. W. White of the Nevada Health Department was informed of the proposed study. General agreement on the objectives listed below was obtained.

Four objectives were established for the study. The first was to measure uptake of radioiodine in fresh unpasteurized cow's milk as a function of time at two separate dairy farms with two groups of cows at each farm -- one group eating hay and grain only, and the other group eating green chop, hay and grain. The second was to measure the effect of green chopping* vegetation on its average radioiodine content. As the third objective, levels of radioiodine in the air would be measured continuously at the two dairy farms as a function of time after a fallout event. The fourth objective was to attempt to relate levels of radioiodine in the air, on vegetation or on the ground to subsequent levels which appeared in fresh unpasteurized cow's milk at the same location.

Arrangements were made to place three cows at each farm on green chop, hay and grain while the remainder of each herd was maintained on hay and grain only. It was not possible under the prevailing conditions to make arrangements for a larger number without imposing an undue hardship on the cooperating farm managers. It should be noted that before arrangements could be finalized, all of the lactating cows at Habbart's were fed one feeding of green chop on the morning of March 17. This was the only time during the study that

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*This is the terminology used for the standard practice of mowing and machine chopping forage from irrigated fields. Green chop is fed to the dairy animals before it dries or spoils.

either whole herd received fresh green chop. Prior to the study no green chop had been fed to any of the cows in either herd.

All animals on green chop at both farms were Jerseys. The specific animals involved in the study were selected by the farm managers and in addition, all were in the late phase of their milk cycles and thus were somewhat below the herd average in milk production. Table 1 indicates the average production of the experimental cows. The average was calculated during the study.

Table 1. Average production of experimental cows.

Identification	Last Calving Date	Milk/Day (lbs.)	Butterfat, (%)
HABBART FARM:			
Kay	July 1963	22.3	4.4
Goldie	July 1963	27.0	5.4
Gretta	July 1963	22.1	4.4
LDS WELFARE FARM:			
60	June 1963	6.3	6.0
40	July 1963	14.6	5.6
30	Nov 1963	19.3	5.9

Dry fed cattle usually have a standard diet of hay, silage, and grain. When silage is fed, the animals are normally fed hay and silage after each milking and grain during milking. When the crops reach cutting size and summer feeding practices begin, fresh green chop replaces the silage. The Habbart operation fed hay and grain throughout this study since the silage had already been consumed.

Table 2. Annual summary of normal feeding practices for this area.

TYPE OF FEED	Estimated total daily feed (lbs./cow)			
	HABBART		LDS	
	Summer	Winter	Summer	Winter
Hay	15	15	15	12
Silage	--	20	--	10-15
Chop	20	--	20	--
Grain	10	10	6	13-15

Part II

SAMPLE COLLECTION

All vegetation and soil samples were collected in clean plastic bags, sealed to eliminate cross contamination and loss of material, and identified as to sample type, location, and time of collection (a. m. or p. m.). Milk and water samples were collected in clean dispcsable one gallon containers.

A. MILK SAMPLING

Pipeline milking systems are utilized at both farms. Three cows are milked at approximately the same time. The milk flows from the cow along a central pipe and drains into a bulk tank.

To minimize difficulty and interference with routine operations, the three cows eating fresh green chop were milked simultaneously either at the beginning or at the end of each milking period. A one gallon composite sample was collected from both the a. m. and p. m. milkings as the milk passed from the drain pipe into the bulk tank.

Milk from the hay fed animals was collected in the same way, except that the composite was a random sample and was not necessarily from the same three animals during each milking. It should be noted that the method of collecting samples from the drain pipe was not effected until March 18. Previous samples

were drained from the bulk tank and sometimes included composites of different milkings. All daily milk results reported are the mean values of the results obtained from the a. m. and the p. m. milkings for that day except when otherwise noted.

B. FEED SAMPLING

Fresh green chop and dry feed were sampled and analyzed for radioiodine content. Also, fresh vegetation was hand cut from the green chopping field at Habbart's and analyzed by the same methods to determine the effect, if any, of green chopping on the radioiodine content. At Habbart's, chop was cut from a stand of barley in a field measuring roughly two hundred yards by one hundred yards. The average height was twenty inches of which sixteen inches were cut for feed. Chopping was done with a tractor driven forage chopper and blown directly into a towed wagon. Fresh cuts were usually made every other day. Soon after each feeding a sample was collected from the trailer in which the chop was loaded. The field at the LDS Welfare Farm was not full, grown so the chopping machine could not operate. Instead, the feed was cut by hand with a scythe. The area cut was a small section approximately sixty feet square that had grown faster than the rest of the field. This section consists mostly of barley with a mixture of alfalfa. The stand averaged thirteen inches and the usual cutting was nine inches. Sample collection was from the feeding trough if available. If it was all eaten, the sample was cut in the field from an area adjacent to the fresh cutting.

Most of the samples from the field consisted of one square meter of vegetation cut to the same level as a chopped sample. For

one study, specific spots were selected to determine if activity was distributed uniformly or had an uneven pattern (see Figure 4). Other samples were random collections, primarily of barley. Alfalfa was collected by the square meter to determine if it had the same retention as barley. The average daily green chop feeding was fifty-five pounds per three cows at Habbart's and sixty-two pounds per three cows at LDS.

Habbart hay was stacked completely exposed to climatic conditions. The cows were fed this hay in a bin which extended the length of the north side of the corral. Random samples were taken from this bin and usually represented a cross section of a bale. Also, some grain pellets were collected and analyzed.

Baled hay at the Latter Day Saints' Welfare Farm was stored in large stacks which were covered only with a protective roof. Silage was stored in a trench silo partially covered with a polyethylene film. Samples were collected from the troughs by the same method used at Habbart's.

C. WATER SAMPLING

Both Habbart and LDS pipe well water to a trough about the size of a bathtub (in fact, one was a tub). The water level is float regulated and remains constant at all times. Samples were collected by immersing gallon containers into the water in such a manner that mostly surface water was collected.

Rain collectors were placed at each farm during the experiment. On April 1, 1964, there was a trace of rain. Also, there was considerable wind and dust throughout the study.

D. AIR SAMPLING

One General Metal Works high volume air sampler was placed at each dairy farm. Mounted on the sampler were a glass fiber prefilter and a Mine Safety Appliances Company charcoal cartridge. Filters and cartridges were changed daily.

E. SOIL SAMPLING

Daily samples were taken by collecting approximately one square foot of topsoil from an undisturbed area at each farm to a depth of approximately one-half inch.

F. BETA PLUS GAMMA DOSE RATE SURVEY

From March 13 to March 17, dose rate readings were taken at each farm with an Eberline Model E-500B portable survey instrument. Dose rate from beta plus gamma radiation was measured both at ground level and three feet above ground in the fields where vegetation samples were collected.

Part III
ANALYTICAL METHODS

Liquid samples were placed in 3.5 liter inverted well aluminum beakers to be analyzed for gamma emitting radioisotopes using a 400-channel analyzer with a 4" x 4" NaI(Tl) crystal detector. Based on fifty minute counts, the minimum detectable level for milk samples is 20 picocuries per liter (pc/l) with an associated error of $\pm$ 20 pc/l, or $\pm$ 10%, which ever is larger. All values were corrected for decay to time of collection. Samples having less than the minimum detectable level of activity at time of count were not corrected to time of collection.

Depending upon size, vegetation samples were packaged in aluminum beakers or in 400 ml "cottage cheese" containers. Since the sample size was non-standard, it was impossible to give a minimum level for I^{131} in pc/kg or pc/M^2. Instead, there was assigned a minimum total activity to 100 pc per sample as the threshold of detection. At 100 pc, the associated error due to counting statistics is $\pm$ 100%. Since the presence of fresh fission products complicates the calculation (standards for some isotopes are not available), a value of $\pm$ 100 pc/kg, or $\pm$ 50%, which ever is larger, was assigned as the best estimate of the analytical error for all gamma analyses of samples other than milk. The presence of Au^{198} made the detection of I^{131} impossible in vegetation samples for about ten days following detonation. The accuracy of I^{131} determinations in soil samples was assumed to be comparable to that of vegetation

measurements.

Air sample prefilters were counted for gross beta activity with a thin window, large area gas flow proportional probe connected to a high speed scaler. The system has an efficiency of approximately 30% for 1.5 Mev beta particles and background for this system is 575 $\pm$ 20 counts per minute. Charcoal cartridges were examined for gamma emitting radioisotopes by placing each cartridge directly on a 4" x 4" sodium iodide crystal coupled to a 400-channel pulse height analyzer set to view energies from 0 to 2 Mev. Assuming no break in the prefilter, the activity on the cartridge should represent the gaseous fission products only. Detection efficiency for this geometry is about 18% at 0.51 Mev. The minimum detectable activity is about 200 pc for any specific isotope.

The analytical limitations as described above are depicted graphically for each datum point in Figures 5 through 11.

Part IV

DISCUSSION OF RESULTS

A. HABBART FARM

Green Chop

A plot of I^{131} levels in milk from cows eating green chop and of I^{131} in the green chop is presented in Figure 5. From the graph, the following observations may be noted:

a. The peak daily average milk value was 375 pc/l, which was obtained on March 21, four days after the cows began to eat the green chop. This average represents the mean value of the a.m. and p.m. milkings for that day which were 420 pc/l and 330 pc/l.

b. The milk values decayed with an estimated apparent half-life of 3.8 days.

c. Extrapolation backwards indicates that if the study had been initiated on March 13, the probable maximum value observed would have been approximately 700 pc/l on March 17.

d. The peak measured green chop value was 4700 pc/kg, which was obtained on March 19.

e. The green chop values decayed with an estimated apparent half-life of 5.3 days.

f. The ratio of the peak average value of I^{131} in milk to the peak value in green chop was 375 pc/l to 4700 pc/kg, or 0.08 pc/l to 1 pc/kg.

The decay half times are in general agreement with published results[1,2,3,4]. The milk decay time is slightly lower than most values from published studies, but is not significantly different from the half-time of four days reported for one case[3]. The ratio of pc/l milk to pc/kg green chop is numerically quite close to the analogous mean Windscale factor[1] of 0.09. Considering the differences in radioiodine sources, climatic conditions and farming practices for the two different cases, such agreement was not expected.

Furthermore, no profound significance should yet be attributed to this finding since the agreement could be due to fortuitous combinations of many unrelated factors. Clearly, additional experimentation is needed. It should be pointed out that the value of 0.08 calculated from our data actually has a possible range, based on analytical accuracy of the two values used to calculate it, of 0.05 to 0.18.

Hay

A plot of I^{131} levels in milk of cows eating hay and of I^{131} in the hay is given in Figure 6. From the graph, one may note the following:

a. The peak measured milk value was 70 pc/l, which was obtained on March 16, three days after the Pike Event. Both the a.m. and p.m. milkings for this day were 70 pc/l. Note that the data for March 18

and 19 should be disregarded since, as mentioned previously, all cows were fed green chop on March 17.

b. The milk values decayed with an estimated apparent half-life of 5.9 days. Again, the points on March 18 and 19 were disregarded.

c. The peak measured level in hay was 1300 pc/kg, which was obtained on March 15.

d. The activity in the hay was so variable that it was not possible to obtain a good estimate of the decay half-time.

e. The ratio of the peak value of I^{131} in milk to the peak value in hay was 70 pc/l to 1300 pc/kg, or 0.054 pc/l to 1 pc/kg. Based on the analytical accuracy of the two quantities used to calculate the number 0.054, the possible range is 0.026 to 0.14. It is not possible to compare these results with published data since, to our knowledge, no one else has observed significant I^{131} values in the milk of cows eating only stored feed.

Distribution Study

Figure 4 depicts several sampling locations in the field at the Habbart Farm from which the green chop was being cut. At each location a one square meter sample was obtained as described previously. The analytical results obtained are also given in

Figure 4. Analyses of these data shows that the mean value of the field sample of I^{131} was 704 ± 253 pc/kg on March 27, where the ± value is the standard deviation. The fact that the standard deviation is less than the estimated analytical accuracy is evidence that the contamination of the field in pc/kg was reasonably homogeneous over the field. Furthermore, the measured I^{131} activity in green chop on March 27 was 740 ± 370 pc/kg. Comparing this to 704 ± 253 pc/kg indicates that no significant I^{131} activity was removed from the vegetation by the green chopping process.

Calculations from these data also show that for this particular field there were 1.34 ± 0.88 kg green vegetation/square meter of surface area.

The mean value of I^{131} on this field on March 27 may also be calculated to be 743 ± 493 pc/M^2 . The large standard deviation shows that the activity in pc/M^2 is considerably less uniform over the field than is the activity in pc/kg. A possible contributory factor is the fact that it was early in the growing season and the barley was not constant in height over the field.

Soil

Figure 7 shows the levels of I^{131} found in undisturbed soil samples at the Habbart Farm. The apparent decay half-life equals 8.0 days, which is precisely the physical half-life of I^{131}. Interpolation gives an estimate of 2500 pc/kg for March 27. Each sample represents approximately one square foot of surface area. In addition, the average soil sample weight was approximately 450 grams. Therefore, for March 27, 2500 pc/kg corresponds to 1125 pc/ft^2 or 12,100 pc/M^2 of undisturbed soil.

On March 27, the vegetation contained 743 pc/M^2 . Consequently, the percentage of I^{131} on the vegetation was 6.1% of that on the soil. In addition, extrapolation back to March 13 gives a deposition estimate for I^{131} of 43,000 pc/M^2 of undisturbed soil.

Comparison of Alfalfa to Barley

Figure 8 presents I^{131} values for barley and alfalfa at the Habbart Farm. The results clearly show that there is no significant difference between the two.

Miscellaneous Samples

Air samples were taken from March 16 through April 10. All results for I^{131} were below the limit of detection of our analytical instruments, indicating that there were no significant secondary aerosols after the passage of the radioactive cloud.

From March 14, to March 17, beta plus gamma surveys at the fields where the vegetation samples were collected registered 0.02 to 0.03 mr/hr, which is normal background for this area. Grain supplement food pellets fed to cows at the Habbart Farm were analyzed for I^{131} content with negative results. This was to be expected since these pellets were protected by storage.

The analysis of water samples collected from the cows' watering trough gave a peak reading for I^{131} of 100 pc/l on March 15. The levels were quite variable for the period March 15 to March 29, averaging approximately 50 pc/l. It is not likely that the well providing water for the cows was contaminated since it is a deep artesian well. Thus the most likely explanation for these findings seems to be that the cows were contaminating the water with their saliva and bits of uneaten food.

B. LDS FARM

Green Chop

A plot of I^{131} levels in milk of cows eating green chop and of I^{131} in the green chop is presented in Figure 9. The following observations may be made:

a. The peak daily average milk value was 65 pc/l, which was obtained on March 20, three days after the cows began to eat the green chop. This average represents the mean value of the a.m. and p.m. milkings for that day which were 70 pc/l and 60 pc/l.

b. The milk values decayed with an estimated apparent half-life of 4.0 days.

c. Extrapolation backwards indicates that if the study had been initiated on March 13, the probable maximum value observed in milk would have been approximately 110 pc/l on March 17.

d. The peak measured green chop value was 1700 pc/kg, which was obtained on March 21.

e. The green chop values decayed with an estimated apparent half-life of 5.3 days.

f. The ratio of the peak average value of I^{131} in milk to the peak value in green chop was 65 pc/l to 1700 pc/kg, or 0.038 pc/l to 1 pc/kg. The possible range on this number may be calculated to be 0.018 to 0.10.

The decay half times are in good agreement with the results obtained at the Habbart Farm. However, the most likely ratio of pc/l of milk to pc/kg of green chop here is less than one-half the one calculated for the Habbart Farm. A possible contributory factor[5] is the relatively much lower average milk production of the LDS cows on green chop vs. that of the Habbart cows on green chop (see Table 1). The green chop I^{131} values here seemed to be lower by about a factor of three than the values obtained at Habbart's Farm.

Hay

A plot of I^{131} levels in milk from cows eating hay is given in Figure 10. Levels of I^{131} in the hay are shown in Figure 11. From these graphs one may note the following:

a. The peak measured milk value was 30 pc/l, which was obtained on March 21, eight days after the Pike Event. Both the a.m. and p.m. milkings for this day were 30 pc/l.

b. The peak measured level in hay was 630 pc/kg, which was obtained on March 20.

c. The values are so erratic as to make any calculation of decay half time for either milk or hay unreliable.

d. The ratio of the peak average value of I^{131} in milk to the peak value in hay was 30 pc/l to 650 pc/kg, or 0.046 pc/l to 1 pc/kg. The possible range on this number may be calculated to be 0.010 to 0.15.

The above results correspond reasonably well with the ones found at the Habbart Farm, but in general the levels are lower by about a factor of two.

I^{131} Deposition per Square Meter

On several days one square meter samples of green chop were taken. From the weights of these samples it was calculated that at the LDS Farm there were 1.08 $\pm$ 0.42 kg green vegetation per square meter of surface area. This agrees with the corresponding value of 1.34 $\pm$ 0.88 for the Habbart Farm.

Soil

The values obtained were too variable to admit the determination of a reasonable half-life of decay. The value obtained for March 26 was 500 pc/kg. The average soil sample weight was approximately 485 grams. Consequently, for March 26, 500 pc/kg corresponds to 242 pc/ft^2 or 2610 pc/M^2 of undisturbed soil. On March 26 the vegetation contained 600 pc/M^2. Thus the percentage of I^{131} on the vegetation was 23% of that on the soil. This is considerably higher than the value of 6.1% calculated for March 27 at the Habbart Farm. A possible contributory factor for this difference may be that at the LDS Farm the forage growth was somewhat spotty and the areas where the forage was cut had higher and more dense growth than the surrounding areas in the same field. If one assumes that the soil levels at the LDS Farm decayed with a half-life of 8.0 days it is possible to extrapolate back to March 13, the day of the Pike Event. This calculation leads to a value for I^{131} of 8050 pc/M^2 of undisturbed soil. This is lower by approximately a factor of five than the corresponding value obtained at the Habbart's Farm.

Miscellaneous Samples

Air samples were taken from March 16 through April 10. All results for I^{131} were below the limits of detection of our analytical instruments.

On March 14 through 17, beta plus gamma surveys at the fields where the vegetation samples were collected registered 0.02 to 0.03 mr/hr, which is normal background for this area.

The analysis of water samples obtained from the cows' watering trough gave low, variable levels of I^{131}, averaging approximately 25 pc/l for the period March 15 through March 29.

Part V

CONCLUSIONS

A brief summary of some of the results pertinent to the first objective is given in Table 3.

Table 3. Summary of results.

TYPE OF SAMPLE	HABBART FARM			LDS FARM		
	Max. Value I^{131}	Time to reach max. (days)	Decay half-life (days)	Max. Value I^{131}	Time to reach max. (days)	Decay half-life (days)
Milk from cows on green chop	375* pc/l	4	3.8	65* pc/l	3	4.0
Milk from cows on hay	70*	3	5.9	30*	8	---
Green chop(wet)	4700 pc/kg	-	5.3	1700 pc/kg	-	5.3
Hay	1300 pc/kg	-	---	630	-	---

*Average of a.m. and p.m. milkings.

This summary plus the appended graphs show the measured uptake and decay of I^{131} in the study cows under the conditions of this investigation. Probably the most significant quantities in Table 3 are the decay half-lives. Even though each specific reported value could be in error by as much as plus or minus one day, it seems likely that there may be a significant difference between the decay in the milk

from cows on green chop and the decay in the milk from cows on hay. The observed time of 8 days for the level of I^{131} to reach a maximum in the milk of cows on hay at the LDS Farm could well be in error by a considerable amount since the measured maximum value of 30 pc/l was quite close to our analytical detection limit.

Within the limits of accuracy of our analytical techniques it is concluded that the process of green chopping forage does not remove an appreciable amount of I^{131}.

Since the air levels of I^{131} were below the limits of detectability of our analytical methods, the third objective of the study was not achieved.

Relationships between peak levels of I^{131} on cow's feed and peak levels appearing in fresh unpasteurized milk at the same location have been calculated and presented. As was shown there is considerable variance to be expected in such relationships since they are determined as the quotient of two quantities, each subject to its own analytical error. Since the external beta plus gamma measurements were background throughout the study it was not possible to calculate relationships between these readings and subsequent milk levels of I^{131}.

It appears that, by a factor of 2 to 5, there was a significantly higher deposition of I^{131} on the Habbart Farm than on the LDS Farm. Since these farms were only five miles apart in a broad valley with no significant topographical features separating them, this finding casts some doubt on the validity of the assignment of contamination values to broad geographical areas based on a single reading at any one location.

Levels of I^{131} in milk of cows on dry feed only were significantly higher than have been reported in other studies. This difference

undoubtedly was due to the common practice in this geographical region of storing baled hay in the open.

Extreme caution should be exercised in attempting to use these data in extrapolating past or possible future situations. It is apparent that there is considerable variance found even in direct measurements as exhibited in Figure 4. 240 pc/M^2 of I^{131} was found in a field approximately 200 yards from a location where a value of 1700 pc/M^2 was measured. Practices of attempting to estimate J^{131} levels which will be found in milk from external gamma or beta plus gamma dose rate readings are particularly subject to question. For example, utilizing such relationships in this instance would have led to the conclusion that there would have been no measurable I^{131} milk levels found whereas our data indicate that levels could actually have reached values near 700 pc/l had the study been started at an optimum time.

Each different source of radioiodine can produce activity of different characteristics which is then further modified by release conditions, meteorological conditions, local climatic conditions and local dairy farming practices. Thus, generalizations which purport to apply to any and all situations are fraught with uncertainty.

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APPENDIX

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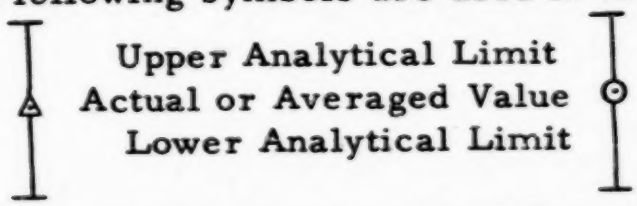
2.	Milk census data collected at the Habbart Farm.	A-2
3.	Milk census data collected at the Latter Day Saints' Welfare Farm.	A-3
4.	Area sampling of Habbart's field for I^{131} activity on March 27.	A-4
5.	I^{131} in Habbart green chop and I^{131} in milk from cows eating green chop.	A-5
6.	I^{131} in Habbart dry hay and I^{131} in milk from cows eating dry hay.	A-6
7.	I^{131} in undisturbed soil at the Habbart Farm.	A-7
8.	Comparison of I^{131} in alfalfa vs. barley at the Habbart Farm.	A-8
9.	I^{131} in LDS Welfare green chop and I^{131} in milk from cows eating green chop.	A-9
10.	I^{131} in milk collected from cows eating dry hay at the LDS Welfare Farm.	A-10
11.	I^{131} in hay from the LDS Welfare Farm.	A-11

Note: The following symbols are used in the Appendix:



For plotting purposes, a value of not detectable is plotted as half the value of the lower detection limit e.g., the lower detection limit for I^{131} in milk is 20 pc/l, any value below this is considered not detectable and is plotted in the following graphs at 10 pc/l.

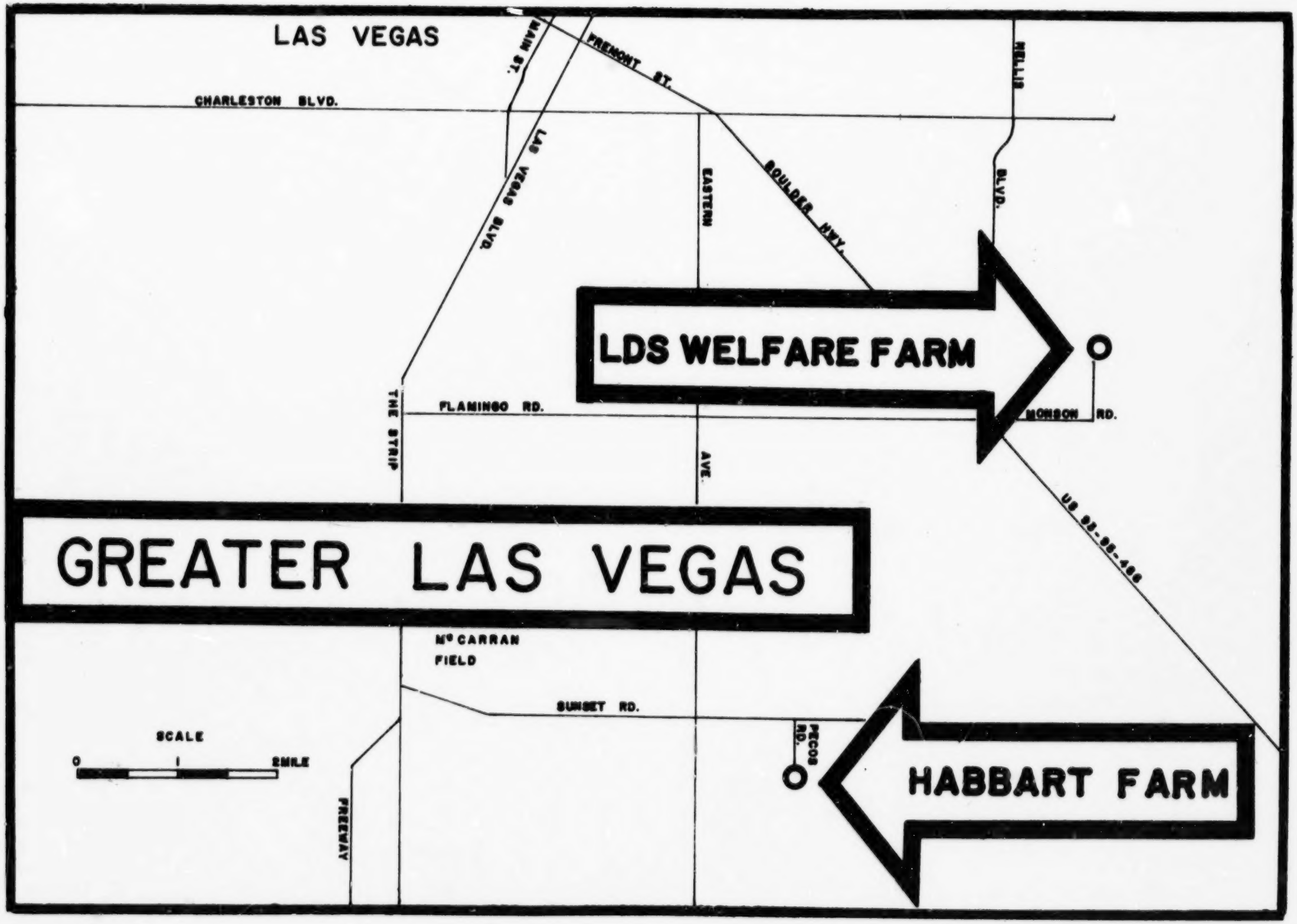


Figure 1. Locations of study farms.

MILK CENSUS FORM

(1) Code: Fig. 2 — Date 3-17-64

Name : Eunice Habbart

Address : 6912 Pecos Road — County (or area) Clark

Location: Las Vegas, Nevada

Population: (Indicate male or female; list children individually)	Age (yrs)	Raw milk consumed daily (in quarts)
Adults:		
(2) 1 Male(s)	Over 18	(3) 1
(4) 2 Female(s)	Over 18	(5) 1
Children:		
(6) 1	10 yrs.	Pasteurized Milk
(7) 1	5 yrs.	" "
(8) 1	3 yrs.	" "
(9)		
(10)		
(11)		
(12)		
(13)		

Home uses of raw milk (qts./day) other than drinking:

(17) Total ____

(18) Garden:

Home ____

Commercial XX

None ____

Crop(s): Alfalfa
Barley
Oats

(14) Total Adults : 3

(15) Total Children: 3

(16) Total quarts raw milk consumed daily: 2

Cattle: Number of Milk Cows: 27 — Breed(s): Jersey, Guernsey and Holstein

Normal feeding practices:	Inclusive dates		Type	Source
	From	To		
(19) Dry feed	Nov.	March	Alfalfa hay	Commercial & field
(20) Pasture	Beef only ---------->			
(21) Grain	Dec.	Dec.		
(22) Concentrate	Dec.	Dec.		

Milk:

(23) Milk shipped to dairy 120 gals/day; Days of milk pickup Mon. Sat. Wed. Fri. Time: varies

(24) Name of dairy and location: Hinies 626 Las Vegas Blvd So., Las Vegas, Nevada.

(25) Grade of milk: (A, B, or C) A

Water Supply:

(26) Domestic use: Surface ___ Municipal ___ Well X Depth Artesian

(27) Cattle source: Surface ___ Municipal ___ Well X Depth Artesian

Other uses: (i.e., irrigation, etc.) Irrigation

(28) Remarks: Quality of pasture? Good pasture. Home pasteurization? No pasteurization at home.

Data collected by: Joel G. Veater

Figure 2. Milk census data collected at the Habbart Farm.

MILK CENSUS FORM

(1) Code: Fig. 3 Date 3-17-64

Name : LDS Welfare Farm

Address : 6206 Munson County (or area) Clark

Location: Las Vegas, Nevada

Population: (Indicate male or female; list children individually)	Age (yrs)	Raw milk consumed daily (in quarts)
Adults:		
(2) 4 Male(s)	Over 18	(3) 4
(4) 4 Female(s)	Over 18	(5) 2
Children:		
(6) 2	16 yrs.	3
(7) 1	15 "	1
(8) 1	14 "	1
(9) 2	10 "	1/2
(10) 2	6 "	1/2
(11) 2	4 "	1/2
(12)		
(13)		

Home uses of raw milk (qts. /day)other than drinking:

(17) Total ____

(18) Garden:

Home ____

Commercial XX

None ____

Crop(s): Hay
Grain
Silage
Pasture

(14) Total Adults : 8

(15) Total Children: 10

(16) Total quarts raw milk consumed daily: 12-1/2

Cattle: Number of Milk Cows: 100 Breed(s): Jersey and Holstein

Normal feeding practices:

	Inclusive dates From	Inclusive dates To	Type	Source
(19) Dry feed	Dec.	April	Hay & Silage	
(20) Pasture	Beef only ----		----------	--->
(21) Grain	Dec.	Dec.		
(22) Concentrate				

Milk:

(23) Milk shipped to dairy 260 gals/day; Days of milk pickup Mon.Wed.Fri.Sat. Time: a.m.

(24) Name of dairy and location: Arden 1000 N. Main, Las Vegas, Nevada

(25) Grade of milk: (A, B, or C) A

Water Supply:

(26) Domestic use: Surface ___ Municipal ___ Well X Depth 200 ft.

(27) Cattle source: Surface ___ Municipal ___ Well X Depth 200 ft.

Other uses: (i.e., irrigation, etc.)

(28) Remarks: Quality of pasture? Home pasteurization? Good pasture. No home pasteurization.

Data collected by: Joel G. Veater

Figure 3. Milk census data collected at the Latter Day Saints' Welfare Farm.

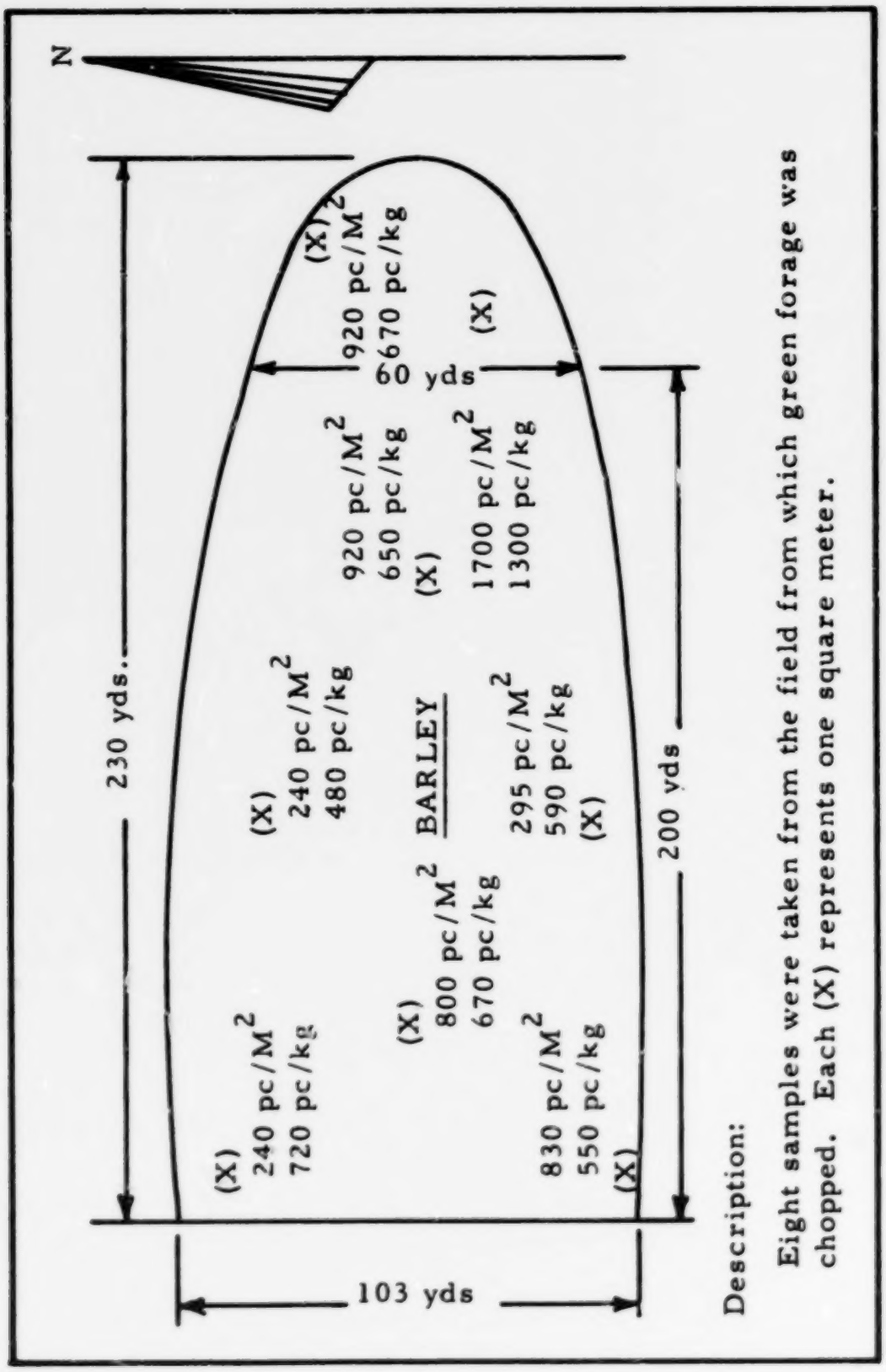


Figure 4. Area sampling of Habbart's field for I^{131} activity on March 27.

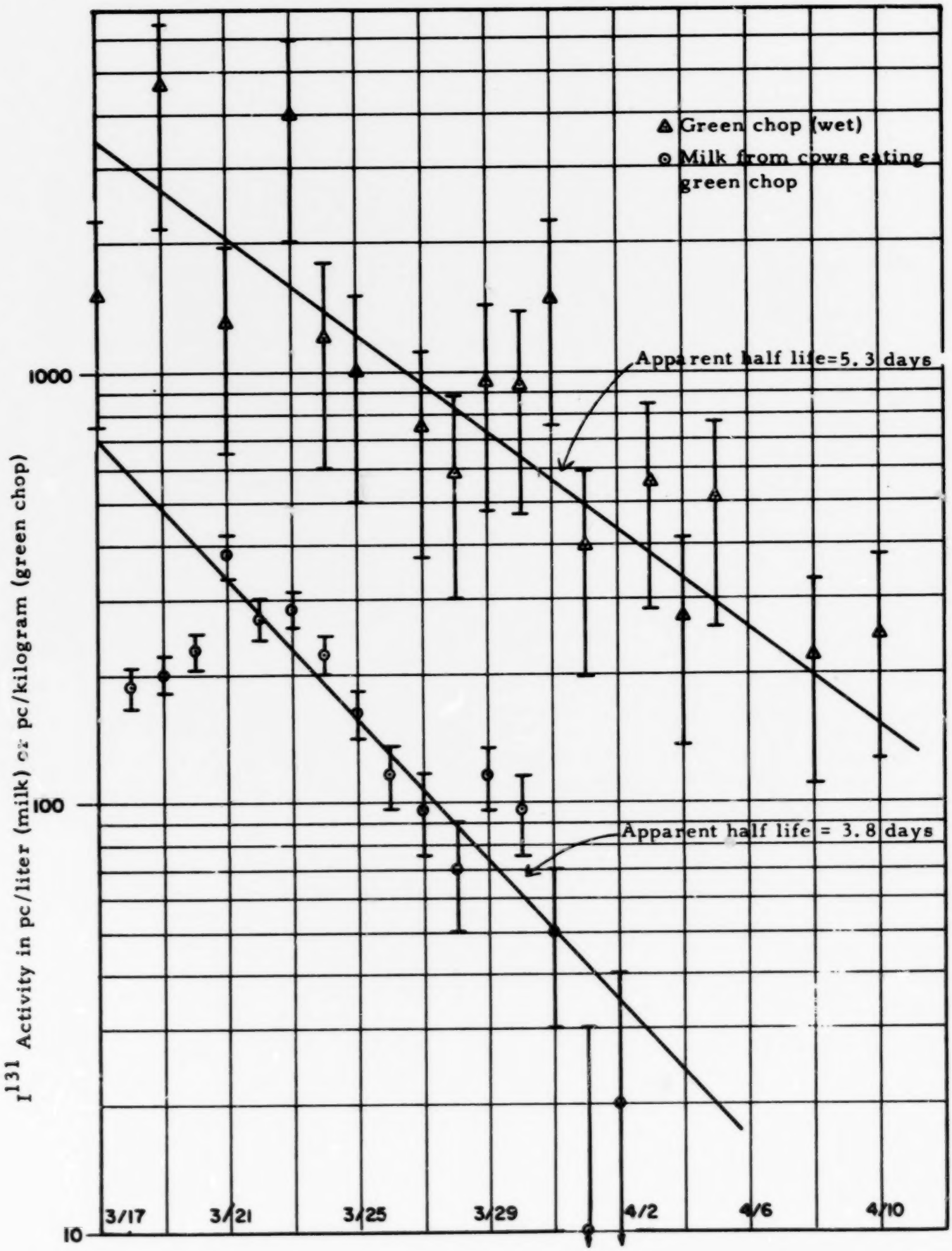


Figure 5. I^{131} in Habbart green chop, and I^{131} in milk from cows eating green chop.

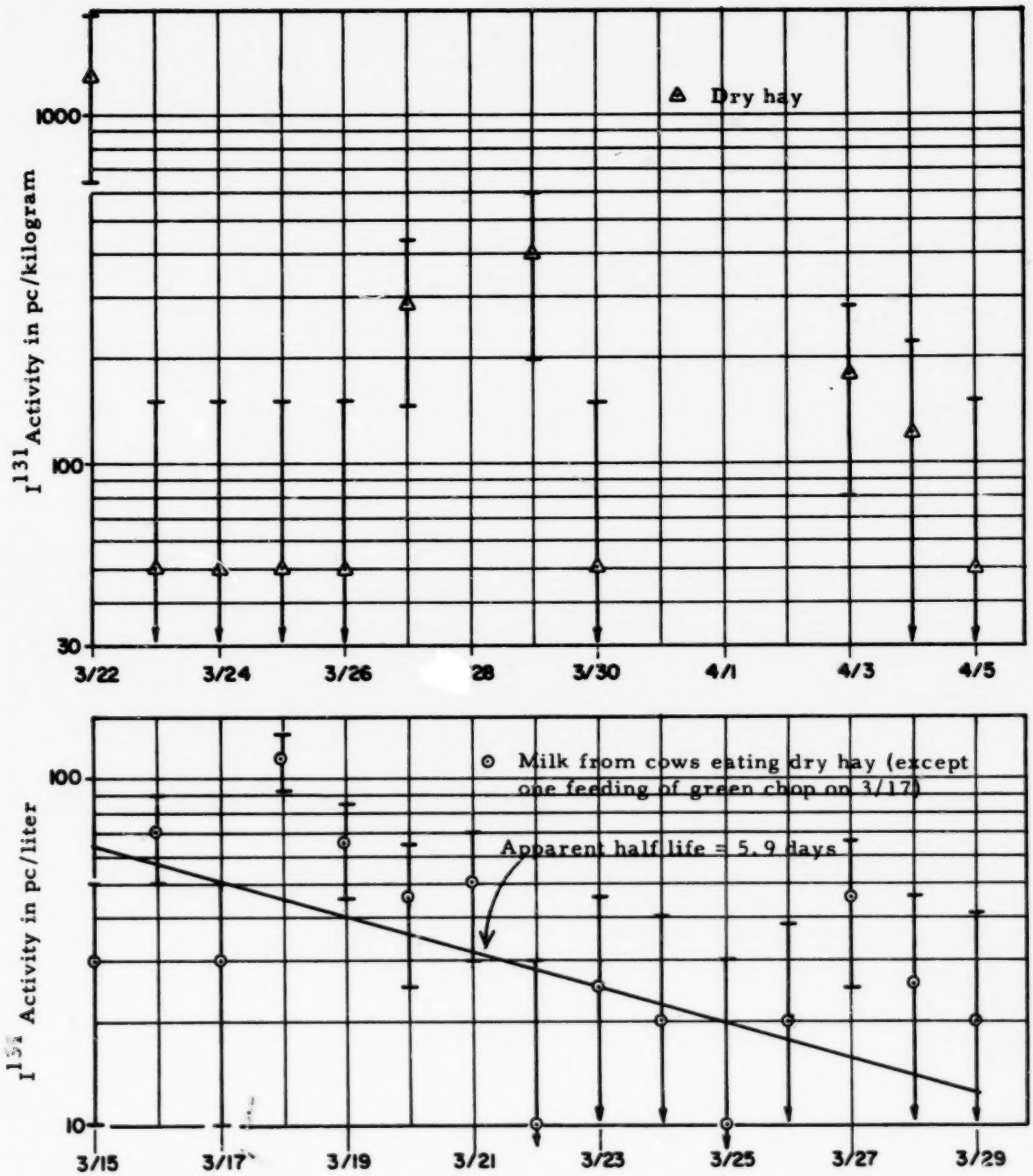


Figure 6. I^{131} in Habbart dry hay, and I^{131} in milk from cows eating dry hay.

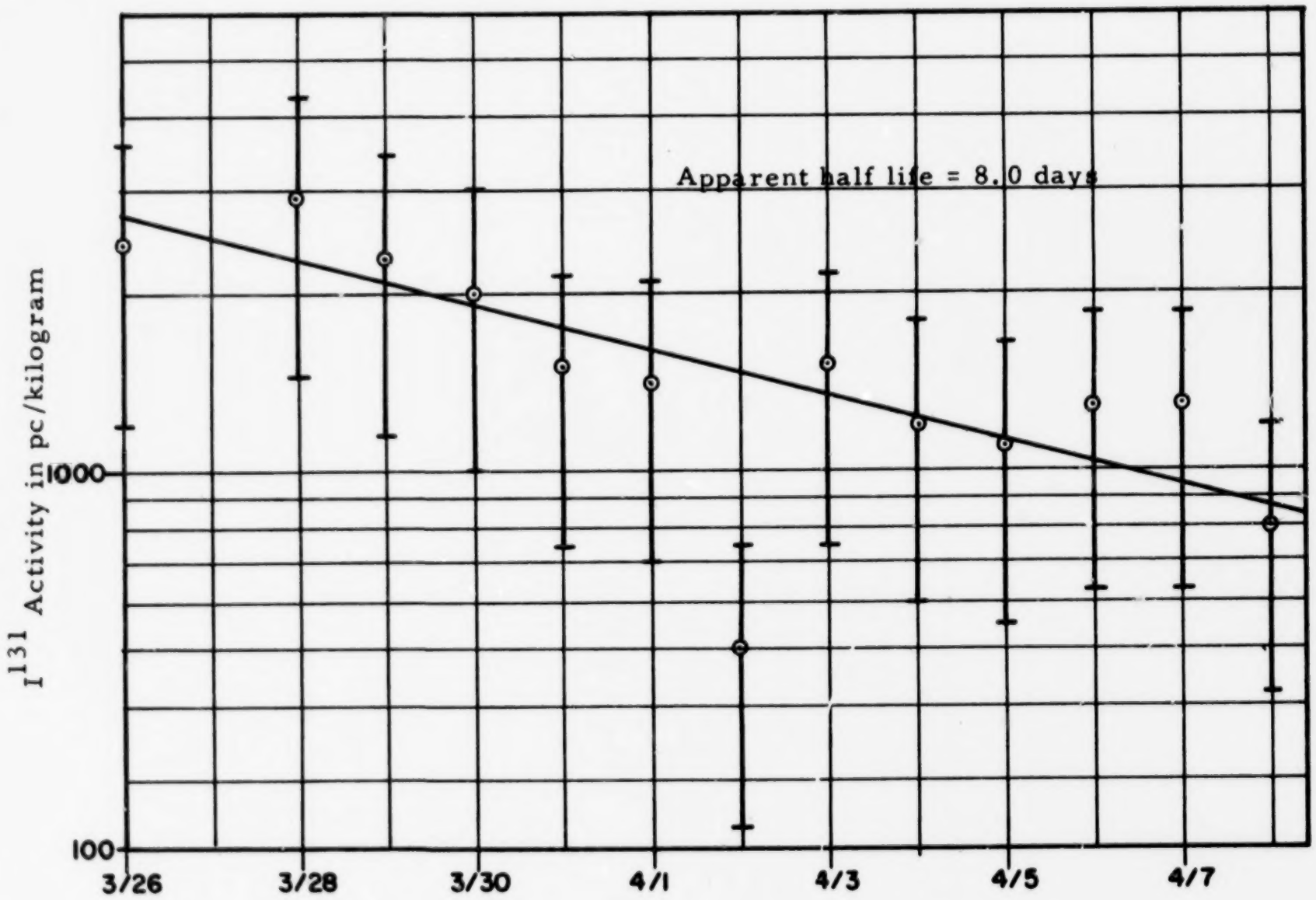


Figure 7. I^{131} in undisturbed soil at the Habbart Farm.

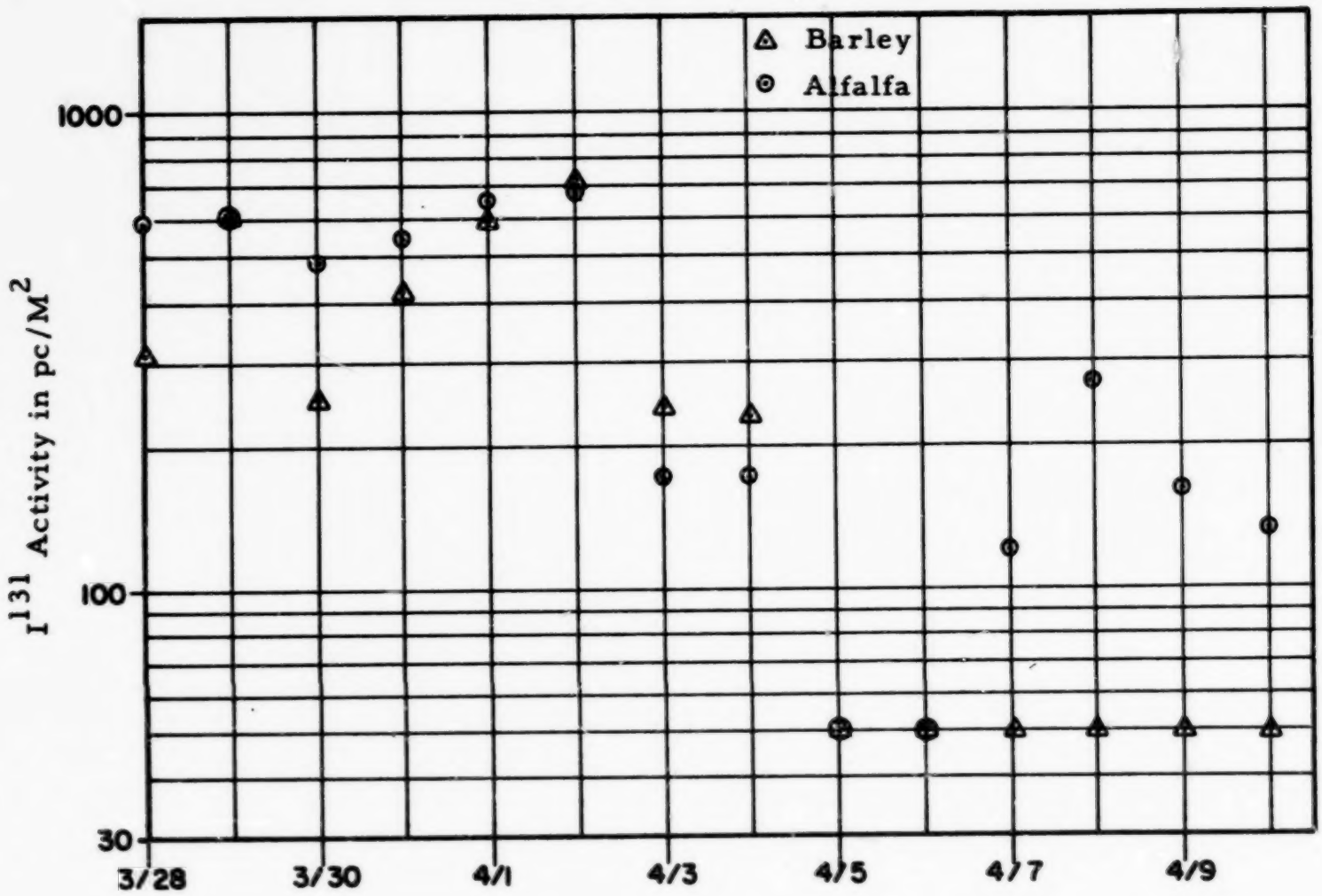


Figure 8. Comparison of I^{131} in alfalfa versus barley at the Habbart Farm.

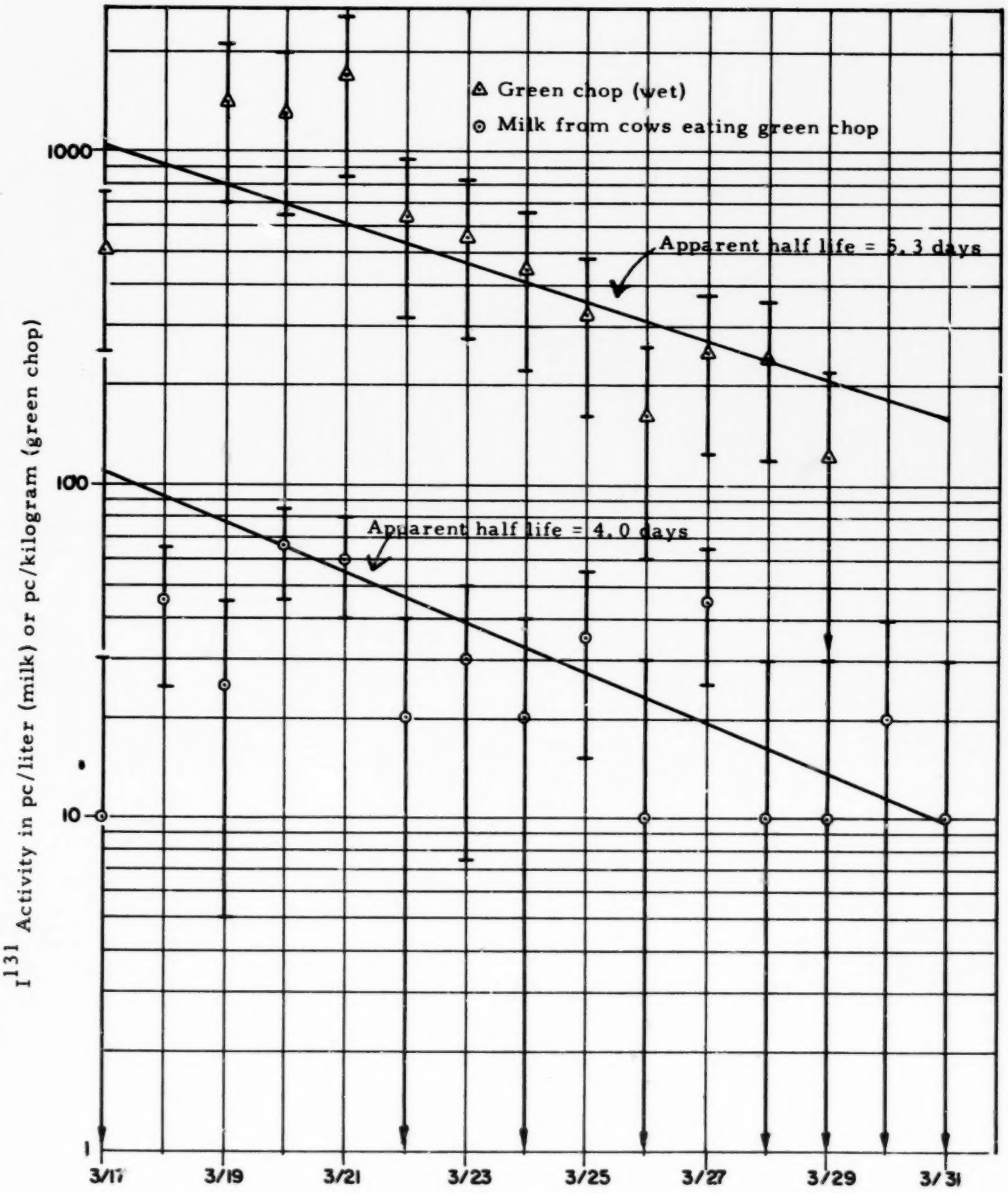


Figure 9. I^{131} in LDS Welfare Farm green chop, and I^{131} in milk from cows eating green chop.

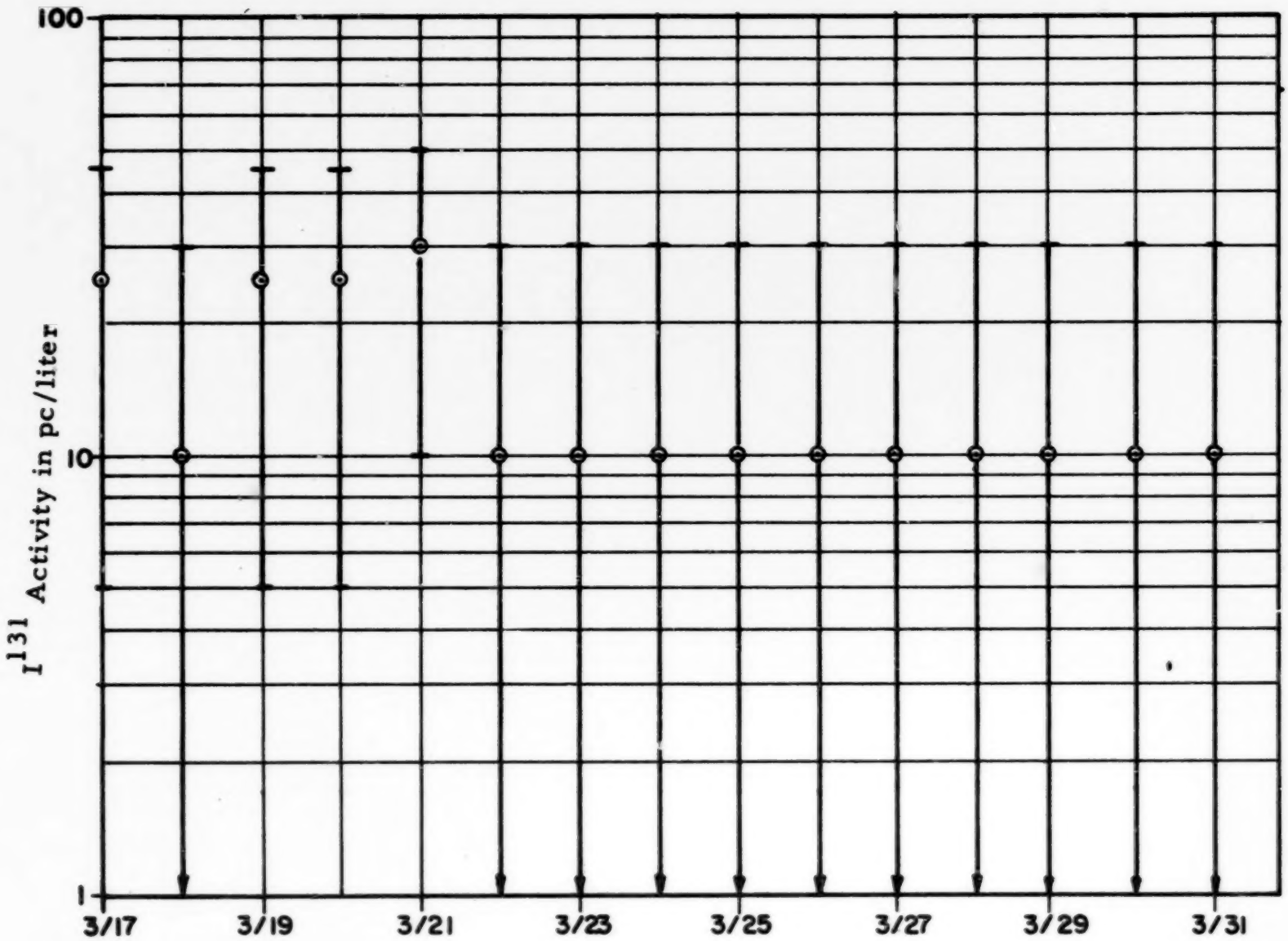


Figure 10. I^{131} in milk collected from cows eating dry hay at the LDS Welfare Farm.

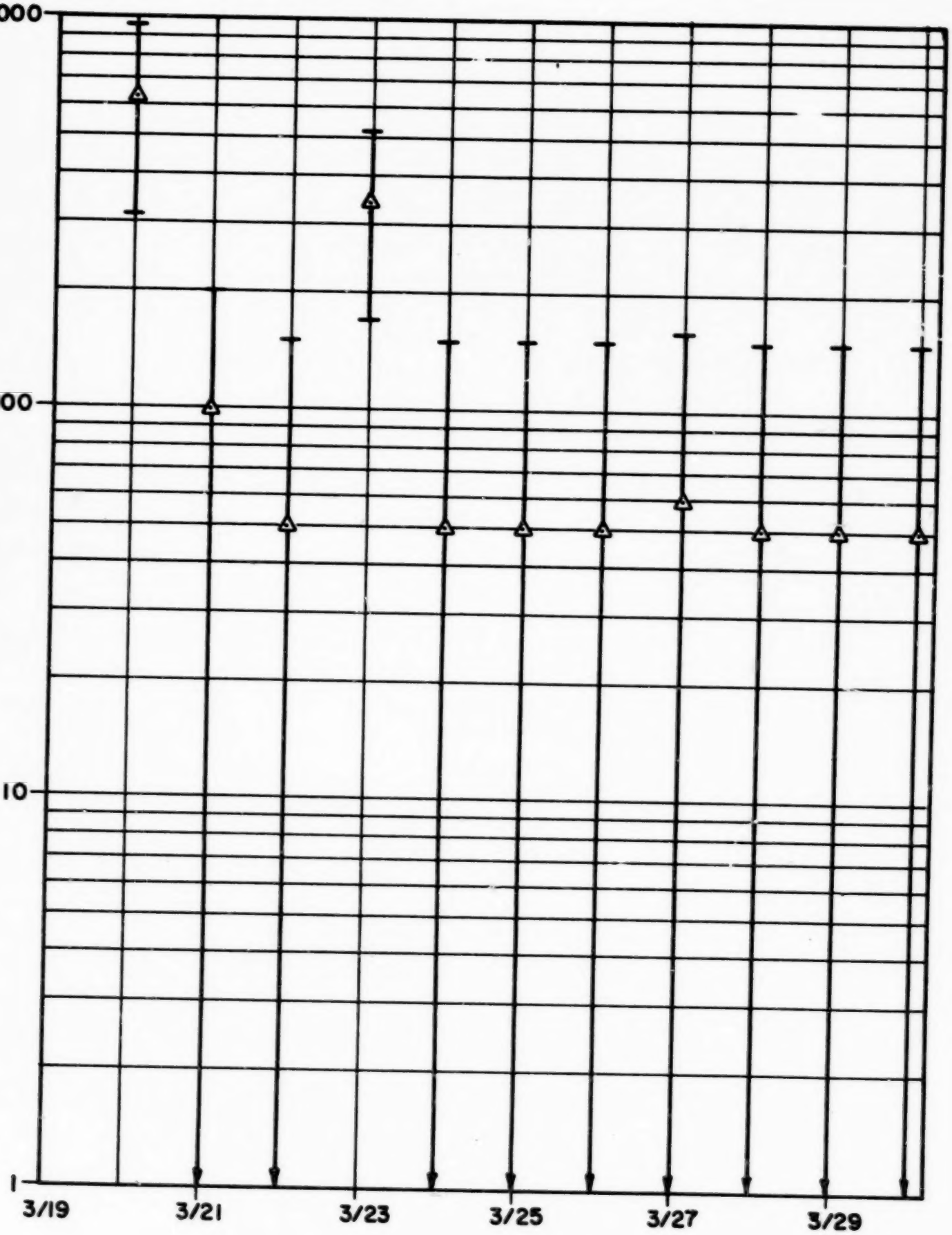


Figure 11. I^{131} in hay from the LDS Welfare Farm.